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ENTOMOLOGICAL SERIES, No. 1.

THE ELM-LEAF BEETLE.

THE SAN JOSÉ SCALE.

ELM-LEAF BEETLE.—*a*, eggs; *b*, larvæ; *c*, adult; *e*, eggs, enlarged; *f*, sculpture of eggs; *g*, larva, enlarged; *h*, side view of greatly enlarged segment of larva; *i*, dorsal view of same; *j*, pupa, enlarged; *k*, beetle, enlarged; *l*, portion of elytron of beetle, greatly enlarged. (*After Riley.*)

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Bulletins.

The Bulletins of this Station are mailed free to citizens of Connecticut and to others who apply for them, until the editions are exhausted.

Applications should be renewed annually before January 1st.

The matter of all the Bulletins of this Station, in so far as it is new and of permanent value, is made a part of the Annual Reports.

☞All Bulletins earlier than No. 71 and also Nos. 83, 93, 100, 101, 102, 106 and 118, are exhausted and cannot be supplied.

Station Reports.

The Annual Reports of this Station, printed at State expense, are by law limited to editions of 12,000 copies, of which 5,000 copies are bound with the Annual Reports of the Connecticut State Board of Agriculture, and distributed by the Secretary of the Board, T. S. Gold.

After exchanging with other Experiment Stations and Agricultural Journals, the reports remaining at the disposal of the Station will be sent to citizens of Connecticut who shall seasonably apply for them, and to others as long as the supply lasts.

☞The Station has no supply of its Annual Reports for the years 1877, 1878, 1879, 1880, 1881, 1883, 1887, 1891, and 1893, but some of them may be obtained from Secretary T. S. Gold, of West Cornwall, Conn., at the cost of postage.

THE ELM-LEAF BEETLE (*Galeruca xanthomelæna*).

Numerous inquiries have reached us lately regarding this insect, which is proving destructive to elm trees in many parts of the State. The beetle (see *c*, *k*, in cut on title page) deposits its eggs, *a*, *e*, in small clusters on the lower side of the young leaves early in June, the larvæ hatch out in about a week and at once begin feeding upon the leaves. These larvæ, *b*, *g*, are small worms about five-eighths of an inch long, marked on each side with a broad blackish stripe. They are soft, moist, and somewhat hairy to the touch. It is at this stage that the insect is most destructive, eating off the delicate surface-tissue of the leaves, and causing the latter to become shrivelled and brown, and eventually to fall from the tree. By the end of June or early in July the worms become full grown. They then crawl down or fall from the trees, and in crevices of the bark or soil or under grass and leaves change to soft, yellowish pupæ, *j*. Ten days later the pupæ give rise to the adult insects, small yellowish beetles, *c*, *k*, about one-quarter of an inch in length, marked on the back with two black stripes. The beetles ascend the tree and for a month feed upon the remaining leaves, though the injury done by them is much less than that due to the worms. During August and the early part of September the beetles enter cracks or crevices, where they secure protection during the winter, and hibernate until late in May, when they appear upon the young leaves to deposit their eggs.* It seems probable that in New England there is but one brood during the season.

Methods of Extermination.—This insect can best be destroyed in the larval and pupal conditions. The larvæ (worms) are found in June and July upon the leaves, the pupæ in July upon the trunks of the trees and on, or in, the ground beneath the trees. *To destroy the worms the best means is a spray of water mixed with Paris green† and fresh slacked lime*, in the proportions of one pound of Paris green and three pounds of lime to one hundred and fifty gallons of water. The lime should be newly slacked and strained free from grit or lumps.

* For fuller information as regards the life-history of this pest, we refer to the recently published Bulletin, No. 14, of the Storrs Agricultural Experiment Station, Storrs, Conn., Prof. W. O. Atwater, Director.

† This dangerous substance, containing arsenic and copper, requires caution in its handling, but may be used without injury if not swallowed nor introduced into wounds.

To reach the tops of high trees a powerful force pump and a long hose are necessary. The Douglas Palmetto spraying pump, manufactured by W. & B. Douglas, Middletown, Conn., is well adapted to this purpose when man-power is employed. It should be mounted upon a cask and raised as high as possible above the ground. The discharge pipe should be a half-inch rubber hose, supported on a light pole, so that the spray can be directed well up into the trees. The best nozzle to use is the McGowan.

While a few trees may be cared for by the use of a hand-pump, the elms in a city like New Haven require much more powerful appliances.

Last year Mr. Stephen Hoyt of New Canaan, Conn., had a steam spraying outfit* constructed, by the use of which the trees upon the estate of Stephen Hoyt's Sons have been treated for two seasons with success.

From their experience, kindly communicated and illustrated to us in all details, we are enabled to present the following plan of treatment by power, adapted for use on a large scale.

A portable steam engine of eight, ten, or more horse-power with a double-acting force pump and a tank of 250 or more gallons capacity, are mounted on a stout wagon with a platform large enough to accommodate the engineer.

The force-pump should be supplied with an indicator to show the water-pressure, and a number of outlets, four, six, or eight, to connect with as many lines of hose as may be practicable. Suitable hose, guaranteed to stand 200 lbs. pressure to the inch and costing 12 cents per foot, may be got of the Mineralized Rubber Co., 18 Cliff st., N. Y. The Lightning Hose Coupling is recommended.

To each hose is attached a nozzle adapted for producing a fine spray. The best nozzle for use with power is the McGowan, made by J. J. McGowan, Ithaca, N. Y., costing $1.50. This with 180 lbs. steam pressure throws a shower of fine spray vertically for thirty feet or more.

The tank, to be charged with the poison drench, should be provided with an agitator to keep the materials in the tank uniformly mixed.

Besides the horses needful to bring the apparatus into position, a driver who can operate the agitator, an engineer, four, six, or

* With 6 horse-power engine, 250 gallon tank, and pump operating 2 lines of hose, each 100 feet long.

possibly eight men to manage as many lines of hose, and an assistant to charge the tank, are the needful force.

A man with creepers ascends a tree, carrying a stout cord, and choosing a good position in a crotch, hauls up a line of hose and fastens it to a limb, so that holding the hose near the end he can direct the nozzle on all sides. The power being applied, the water, with the poison in suspension, is forced out of the hose in a shower of fine spray, which, by skillful handling of the nozzle, is quickly applied to all parts of the foliage. To avoid waste of liquid the spray is thrown for a moment only on any one point, one, two or three minutes at the most sufficing to finish work on large trees.

While two or more men are directing the spray into as many trees, the same number are climbing the adjacent trees, so that the engine and its attendants are fully occupied.

Two treatments are advisable, the first in May as soon as the leaves are half grown, in order to destroy the beetles before they deposit their eggs; the second in June or as soon as it is seen that the eggs which have been laid are hatching out. This is undoubtedly the most effective method of combatting the insect, and should be kept up for several years.

Trees which, like many in New Haven and elsewhere at this writing (July 16), have lost one-half or more of their sound leaf-surface may be expected to survive the present attack, but to be destroyed beyond remedy by the myriads of beetles and worms that will appear next year, unless a well organized campaign for their suppression is undertaken early next spring.

If, for any reason, the spraying of the trees is impracticable, efforts must be made to *destroy the insects in the pupal condition on or beneath the trees.* This is best done by the use of *kerosene emulsion*, which is made as follows: Dissolve one-half pound of common hard soap in one gallon of boiling water; to this soap solution, while still hot, add two gallons of kerosene, and churn violently for five minutes until a creamy emulsion results, p. 14. Dilute this by stirring with nine times its bulk of cold water, and sprinkle it freely over the ground through a watering-pot. The application, which is not injurious to grass, should be made in such a quantity as to saturate the soil where the pupæ exist. By carefully examining the ground, grass, fallen leaves, etc., beneath the trees, the pupæ can be found, and the proper time for applying the emulsion as well as the extent of ground demanding

treatment can be ascertained. In this climate the soft, yellow pupæ will be found on the ground from the middle of June to the middle of July or later, according to the season. The emulsion should be applied as soon as they are observed and the application repeated if needful to destroy them. To be thoroughly effective this method of destroying the pupæ must be practiced each year.*

It is well to scrape away the rough outer bark of the trees for some distance above the ground, as many pupæ are likely to be concealed in the crevices. The scrapings evidently should be burned or drenched with kerosene.

Very many descending *worms are easily intercepted by a band of hay* an inch thick and 8 inches wide, secured to the scraped trunk at convenient height from the ground, by aid of a 6 in. girth of cheap cotton cloth, which is first tacked by one end to the bark and after packing the hay under it around the tree, is fastened at the other end by pins.

As often as the hay gets stocked with worms and pupæ, the band (but not the naked bark) is hammered with a mallet to crush most of the vermin.

Thereupon the hay with any live insects is burned and replaced by a new band.

THE SAN JOSÉ SCALE.

By Wm. C. Sturgis and W. E. Britton.

Occurrence in Connecticut.—The appearance of the San José scale (*Aspidiotus perniciosus*) is an event of very great importance to all our fruit growers. The objects of this paper are to call attention to this dreaded pest, to enable the reader to recognize the scale, and to indicate remedies that will check its further spread.

During a visit to the orchard of Mr. Joseph L. Raub of New London, on June 12th, we were struck by the appearance of certain young peach trees which were then apparently dead, though earlier in the season they had put out a few leaves near the tips, and last year had been exceptionally vigorous. Close inspection showed that in every case the trunk and larger limbs were fairly

* While the touch of very little kerosene to the bodies of larvæ and young pupæ is fatal, the emulsion may fail to destroy hairy worms or older pupæ, because the hairs of the former or the "chitinous" membranes of the latter shield the soft and vulnerable parts from actual contact with it.

incrusted with a grayish coating composed of vast numbers of scale insects. These so resembled the published drawings of the San José scale, Fig. 1, page 8, that they were suspected to be that pest. Specimens were at once submitted to the experienced entomologists, Messrs. L. O. Howard of the U. S. Department of Agriculture and M. V. Slingerland of Cornell University, who kindly examined them and confirmed our conclusion. The specimens secured on June 12th were small and undeveloped, having apparently died while still in the hibernating condition. On June 20th, careful notes were taken of the condition and surroundings of the orchard, which occupies an isolated position on the outskirts of the city, with no other orchard in its vicinity, and which contains a variety of fruit trees from one to four years of age. It was evident that the scale had not come from the neighborhood, but it was still more evident that the orchard in its present condition might be a fertile source of infection, for living scales were found upon fully one-half of the trees. All the trees came originally from a firm in New Jersey, and were set out in or since 1891. The plantings of 1891 and 1892 were very badly affected, many of the trees being completely dead and covered with the scale, others being killed to the ground but sending up new shoots from the roots. Living scales were found principally upon the trees set out in 1893, but the insect had not yet completely infested the trees, which remained comparatively vigorous. The trees set out last year were practically free from scale. From these facts it is evident that the insect was introduced upon the stock of 1891 and 1892 and had developed until the trees died; and that the stock of 1893, while originally infested equally with the previous plantings, had remained sufficiently vigorous to show but little evidence of the attack. Doubtless, however, these trees offered suitable conditions for the breeding of the pest and its spread to the still unaffected trees of the planting of 1894. The freedom from scale of the last was undoubtedly due to the energetic and successful measures adopted in 1894 by the New Jersey firm to eradicate the scale from their nurseries by the destruction of all infected trees, and the fumigation of all suspected stock before placing it upon the market.

Since our first visit, Mr. Raub has undertaken to destroy the trees in his orchard which are most seriously infested, and to apply to the others a strong solution of whale-oil soap. This will undoubtedly check the spread of the scale until next winter, when more drastic remedies can be applied to the dormant trees.

General appearance of the Scale.—When the scales occur singly they are not easy to detect with the naked eye; but when, as is usually the case, they occur in groups, they are easily seen as a grayish and roughened or pimply coating upon the bark, as shown in Fig. 1. This coating, when scraped off with the

FIG. 1.—San José Scale: Apple Branch, with scales—natural size.—(From *Insect Life.*)

thumb-nail or with the blade of a knife, appears mingled with a yellowish liquid if the insects composing it are alive. In severe cases the bark is completely covered with this scaly coating, and upon removing the bark the delicate tissues beneath are seen to present a pinkish or purplish color. When a tree is but slightly affected, the scales are usually found singly or in small groups upon the twigs, often at the base of the leaves. When the scales occur upon the fruit, it is usually in the form of scattered individuals closely attached to the surface, each one being surrounded with a purplish ring, Fig. 2. The separate scales measure, when fully grown, about one-eighth of an inch in diameter, are almost circular, slightly convex with a minute blackish projection in the center, and are of a dirty brown or gray color. The scale may be easily lifted upon the point of a pen-knife, and the insect beneath it, if alive, is seen as a small bit of yellowish jelly. This scale differs in appearance from other scales commonly found upon fruit trees; it is rounder than the "oyster-shell bark louse," and is smaller and darker in

color than the "scurfy bark louse." In fact it is the only scale among those commonly found on fruit trees in Connecticut, which is distinctly circular in outline.

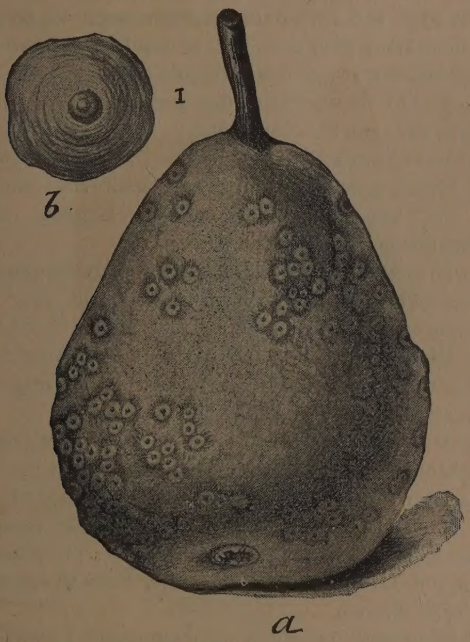

FIG. 2.—San José Scale: *a*, Pear, moderately infested—natural size: *b*, female scale—enlarged.—(From *Insect Life.*)

Effect of the scale on the trees.—The pernicious effects of the San José scale are in a great measure due to its inconspicuous character, and to the fact that its effect upon the vitality of the tree is not at once apparent. During the first season of its attack, the tree may be apparently healthy, with full leafage and abundant fruit. As the scale spreads, however, the effect becomes more plainly visible, though it is such as might readily be attributed to the attacks of borers or to drought. Only the most careful observation will discover the true cause of disturbance. Generally by the second or third season only does the scale become so abundant as to be conspicuous, and by that time the whole tree is infested with the grayish coating of scales; in its weakened

condition it succumbs easily to an exceptionally severe winter, and though it may put forth leaves, they shortly wither, and before the cause of the trouble is actually known, the tree is practically dead. If taken in time, however, it is not difficult to check its ravages, and we would therefore urge all fruit-growers to inspect their trees with care, and to send us specimens of any insect found bearing resemblance to this scale.

Plants subject to the attacks of the scale.—The San José scale has been thus far found in Connecticut upon the Peach, Apple, Pear, Plum and Currant, but information from other States shows that it may attack most of our large and small fruits, and the rose, hawthorn, elm, basswood, alder, sumach, English walnut and various evergreens.

Origin and spread.—This insect was formerly supposed to have been introduced into California from Chili, in the year 1870, but later information obtained by Mr. L. O. Howard, Chief of the Division of Entomology, U. S. Department of Agriculture, seems to show that the Pacific coast was probably its original home, whence it spread to Chili and other countries.

It was first noticed by fruit shippers near San José, Santa Clara County, California. No exterminative measures were taken and a few years later the Pacific slope was largely infested.

Prof. J. H. Comstock first described it in the report of the U. S. Department of Agriculture for 1880. He found it doing much damage in California and regarded it as the most destructive scale insect known.

The Atlantic States, however, were supposed to be uninfested until the summer of 1893, when it appeared upon orchard trees in Charlottesville, Va. The attention of Dr. C. V. Riley, then U. S. Entomologist, was called to the fact of its presence, and measures for its suppression were immediately employed.

It was soon discovered that this was not the only center of infection, but that the scale existed at De Funiak Spring, Florida; Bartle, Indiana; Neavitt and Chestertown, Maryland; Lewisburg and Atglen, Pennsylvania, and in several localities in New York and New Jersey. It has recently been found in Delaware and on Long Island.

The introduction of the San José scale into the Eastern States has been traced to the importation of Japanese plum trees into New Jersey from California.

Like other scale insects, the San José scale can spread only a short distance each year, unless its distribution is aided by the agency of wind, water, or animals.

Probably its distribution in this country has been largely effected through shipments of fruit and nursery stock; but the insect has been found upon other insects, and these, especially the flying ones, have doubtless assisted in its dissemination.

Life History.—This insect is viviparous; i. e., brings forth living young, Fig. 3.

FIG. 3.—San José Scale insect: *c*, adult female containing young—greatly enlarged: *d*, anal fringe of same—still more enlarged.—(From *Insect Life.*)

In California three annual broods appear, but for our climate the number of yearly broods has not been definitely determined.

The San José scale survives the winter either in the egg or in a half grown state. It becomes fully developed and reproduces about the last of May or first of June, and successive broods appear until winter begins.

The newly born or hatched individuals, Fig. 4, unlike their female parent, have no scaly covering but crawl about like ordinary plant lice. They are very small at first. The period of activity lasts but a day or two, sometimes only a few hours, when the young insects settle upon the bark and become fixed.

The scaly covering then begins to form. The insect soon molts and the cast-off skin uniting with a waxy secretion forms the visible external scale.

FIG. 4.—San José Scale insect: *a*, young larva—greatly enlarged: *b*, antenna of same—still more enlarged.—(From *Insect Life*.)

The female insect cannot change her place after the scaly covering begins to form, but the male is able to emerge from his cover, and being winged can travel short distances, Fig. 5.

Remedies.—As soon as the scale is discovered, and before any wash or other treatment is applied, the trees should be cut back as severely as seems advisable, and all the cuttings burned, as, in the case of newly infected stock, most of the scales occur on the terminal shoots.

Gas Treatment.—This requires an oiled canvas or some other gas-tight tent in which the tree is enveloped. Hydrocyanic acid gas is then generated by pouring, say three fluid ounces of water into an earthen-ware vessel, adding one fluid ounce of commercial sulphuric acid (oil of vitriol), and lastly one ounce (by weight) of fused potassium cyanide, these materials making enough gas to fill a space of one hundred and fifty cubic feet.

If this treatment is employed, the greatest caution must be taken not to breathe the gas, for hydrocyanic (or prussic) acid is a most dangerous poison.

According to Lintner (Bull. N. Y. State Mus., Vol. 3, No. 13, p. 302) Mr. Howard lately reports the gas treatment as not wholly efficacious in Virginia, possibly owing to the more complete dormancy of the insects in the East than in California, where it was first successfully employed.

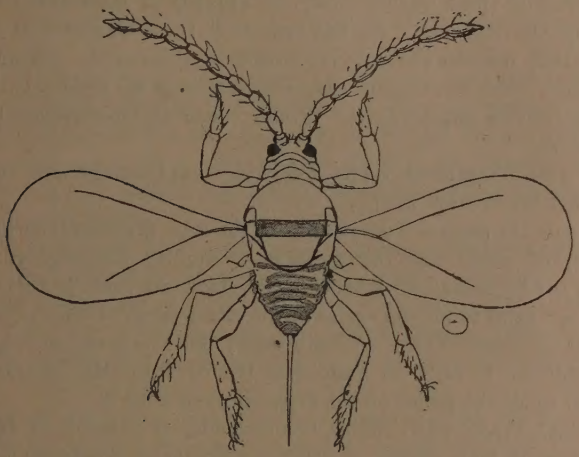

FIG. 5.—San José Scale insect: male adult—greatly enlarged.—(From *Insect Life.*)

Summer Treatment.—Either weak rosin wash or dilute kerosene emulsion is advised for keeping the scale in check during the Summer. Neither will do more than this, since the young hatch out at intervals throughout the Summer, and this treatment will not kill the mature scales.

The following formulas are recommended :—

WEAK ROSIN WASH.

Rosin	20 pounds
Caustic soda	5 pounds
Fish-oil	2½ pints
Water to make	100 gallons

Pulverize the rosin and soda, add the oil, and place the mixture in a large kettle with water sufficient to cover it. Boil for one or two hours with occasional additions of water, until the compound will mix perfectly with water instead of breaking up into yellowish flakes. Dilute for use to 100 gallons.

STANDARD KEROSENE EMULSION.

Kerosene	2 gallons
Common soap or whale-oil soap	½ pound
Water	1 gallon

Heat the solution of soap and add it boiling hot to the kerosene; churn the mixture by means of a force pump and spray nozzle for five or ten minutes. The emulsion, if perfect, forms a cream which thickens upon cooling, and should adhere without oiliness to the surface of glass. If the water is hard, add a little lye or soda, enough to make it feel very slightly slippery. For use, dilute with nine times its bulk of cold water.

Either of these washes should be applied at least three times during the Summer. As has been said, these washes will do no more than prevent the serious increase of the insects during the Summer. For thoroughly effective treatment we must rely upon strong washes applied in the Winter, when the trees are not liable to injury.

Winter Treatment.—The following applications are recommended for Winter use:

Whale-Oil Soap.—Two pounds of the soap are dissolved in one gallon of water and this solution is applied thoroughly, as a spray, or by means of a brush. Mr. Howard records this solution as "fatal to all the scales on the trees sprayed with it."

Strong Rosin Wash.—A rosin wash, made as given on page 13, but diluted to only 16 gallons, is recorded by Mr. Howard as "fatal to all the scales on the trees sprayed with it."

Potash Wash.—Dr. Smith recommends, as a result of his experiences in New Jersey, a wash consisting of a saturated solution of crude or commercial potash, i. e., potash in a quantity of water just sufficient to dissolve it. This is applied with a cloth or a brush, or as a spray. The potash serves to corrode and loosen the scales, killing many of the insects beneath them; and a spray of kerosene emulsion a month later completes the work of destruction.

On the whole, the Winter treatment with whale-oil soap, or strong rosin wash, seems to leave nothing to be desired, while in order to keep the insect in check during the Summer, or until this treatment can be safely applied, either of the two Summer washes described above will prove valuable.

Winter Treatment should be applied soon after the leaves fall, as the scales are thought to be more susceptible at that time than later in the winter.

Summer Treatment should be applied at least three times at intervals during the summer. Frequent rains necessitate repeated applications.

SUMMARY.

THE ELM-LEAF INSECT winters in crevices of the bark in the *beetle* form, which feeds on and *perforates* the young leaves, and, late in May, lays eggs on the under surface of the same. In early June the *larvæ* or "worms" hatch out and consume the soft leaf-tissue. During late June and in July the larvæ mature, descend the trunk and pupate in crevices of the bark or ground. The *yellow pupæ*, in a week or two, develop into beetles, which ascend the tree, feed on the leaves somewhat until cold weather, and then hibernate.

This insect may be fought in all its three maturer stages, but is most effectually attacked by thoroughly spraying all the foliage of infested trees with Paris green, at least twice in spring-time, viz : 1st, in May usually, before the beetles lay their eggs on the half-grown leaves, and 2d, in June, or when the young larvæ begin to appear. (pp. 3–5.) If heavy rains wash the poison off the leaves soon after it has been applied, the spraying should be at once repeated, since the insects are killed only by eating the Paris green.

In default of effectual spraying of the foliage with Paris green, the descending larvæ, and especially the pupæ, may be destroyed by kerosene emulsion applied to the tree-trunk and the surrounding ground (p. 5), or they may be trapped in bands of hay, cotton or other material that furnishes a place suited for the process of pupation. (p. 6.)

THE SAN JOSÉ SCALE INSECT, which has appeared in New London, Conn., occurs at first as a very inconspicuous grayish pimply coating on the bark of the young twigs of various fruit and other trees, and spreads in two or three years to cover all the stem, and finally appears on the fruit. (Figs 1 and 2, pp. 8, 9.) The separate scales are circular in outline, when fully grown are of about one-eighth inch diameter, and, if covering the living insect, yield a yellowish liquid when scraped or crushed.

Trees upon which this insect has once become established are doomed to a slow but certain death, and are centers of a surely spreading infection unless the pest be early discovered and promptly exterminated by the thorough use of suitable remedies.

Summer treatment, at least twice repeated, with "Weak Rosin Wash" or Kerosene Emulsion" (pp. 13, 14), serves to hold the insect in check, but—

Winter treatment, or rather Autumn treatment, soon after the leaves fall, with "Whale Oil Soap," strong Rosin Wash," or "Potash Wash," is essential to destroy this most pernicious parasite.

Prevention of the ravages and spread of the San José scale requires immediate and strict attention to all existing orchards and most careful scrutiny of all scions and nursery stock brought from without. All prunings, fallen wood or fruit, that close inspection does not show to be clean of this scale, should be destroyed by fire.